IoT Based Irrigation System Powered by Solar Energy

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Abstract

Irrigation of the agricultural sector is a major problem facing most farmers now a days. The problems associated with irriagation are over-irrigation, under-irrigation and manual labour. This paper presents a solar powered IoT(Internet od Things) based irrigation system for paddy fields to have an insightful approach for overcoming labour-intensive work and also to track the water management system. The mian aim is to diminish conventional methods of irrigation and support an intelligent way of watering the paddy fileds to conserve water and limit the over or under irriagation. The system is designed to be powered by a photovoltaic panel that enables smooth operation even during power cuts. The microcontroller is the heart of the device. Two microcontrollers are used to process the data, one of which is integrated with a humidity sensor, a temperature sensor and a humidity sensor. The inputs from these sensors are fed to the first microcontroller and these values are used to activate a solenoid valve that starts irrigation on the basis of soil moisture requirements. The output of the fisrt microcontroller is also fed to the second microcontroller unit, and the data is fed to the ThingSpeak platform, a cloud server powered by Mathworks. Thus, the irrigation cycle takes place without human intervention and can be tracked remotely from any part of the world.

KeyWords: Arduino, Humidity, Internet of Things, Irrigation, ThingSpeak, Temperature

1. INTRODUCTION

Agriculture plays an important role in our country's growth. Problems related to agricultural often hamper the economy [1]. The population of India has reached 1.3 billion, and is rising day by day. At the current pace, significant problems will emerge with food shortages and water consumption. Also, the farmers now use an age-old methodology for irrigation for paddy that is known to be ineffective [2]. To date most farmers have been using conventional farming irrigation techniques. Particularly for paddy, where they use a technique known as flood irrigation in which water is left standing during the growing season. Nearly 50% of the water percolates into the soil and another 20% evaporates and the remaining 30% is what the crop needs. This paper focuses primarily on addressing the problem of over-irrigation, under-irrigation and manual labour. In addition it saves the farmer's time, money and electric energy.

Knowledge in electronics and computing has been used in recent years to solve most of the challenges in agriculture [3-5]. The microcontroller had been at the forefront of the electronics revolution. Together with various sensors the microcontroller is used to calculate and monitor physical quantities such as temperature, humidity, heat and light.

This paper proposes an IoT-based paddy irrigation system powered by solar energy, A clever approach for managing labor intensive work and even for regulating water management systems. The key objective is to reduce traditional watering methods and to encourage genuine water use methods that strengthen the proper irrigation system. Also, to utilize the abundantly available solar energy as a source of energy to the proposed concept also contributes to uninterrupted running of the process.

The researchers have proposed various automatic irrigation system based on GSM and SPRS in the past decade [6-11]. The major drawbacks of the proposed systems are automated drip system is very sensitive to clogging, costly and human error in setting the control values.

2. DESIGN AND IMPLEMENTATION

The proposed system is designed to power by solar energy. The charge controller is used between the battery and the solar panel to prevent the power from flowing back to the panel, to regulate the power flow and the circuit will also prevent the battery from being overcharged. The energy is fed from the charge controller into the entire device. The system is further divided into two major units namely control unit and receiving unit

a. Control Unit

The control unit is the heart of the system. It consists of an Arduino UNO which has Atmel320p micro-controller and it acts as the brain of the system thereby controlling all the devices connected to it [12-15]. The YL-69 soil moisture sensor, DHT-11 humidity and temperature sensor, 5V single channel and 12V solenoid valve is connected to the Arduino. The Arduino gets data of the soil moisture content, humidity and temperature from the soil and this data is used to compare with a prefixed threshold value. If the values obtained from the soil do not fall within the designed constrained value, the micro-controller triggers the solenoid valve with the help of the relay connected. Also this Arduino sends data to the receiving unit through the Nrf24l01. The components used in control unit are given in Table.1

Table 1. Components used in Control unit

SI No	Component
1	Arduino uno
2	NRF24l01
3	Solenoid valve
4	DHT11 sensor
5	YL-69 soil moisture sensor
6	Relay
7	Batteries 12V 1.3A/h, and 9V

b. Receiving unit

This unit consists of an Arduino which receives data using the nRF24l01. This data is later sent to ThingSpeak platform using the ESP8266 module.

The architecture of the suggested system is shown in the Fig.1, it mainly consist of control unit and receiving unit as discussed.

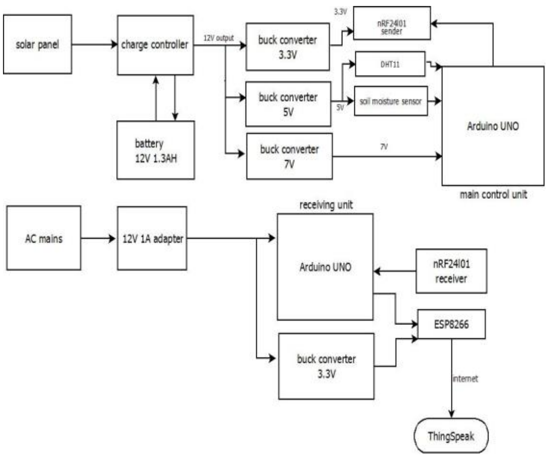

Fig. 1 Architecture of the proposed design

The connection diagram of the control unit and its implementation on the breadboard are depicted in the Fig. 2 and Fig. 3 respectively.

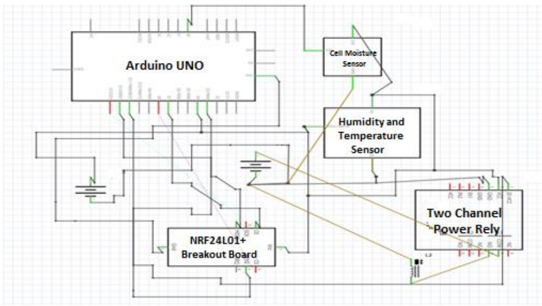

Fig. 2 Connection diagram of control unit

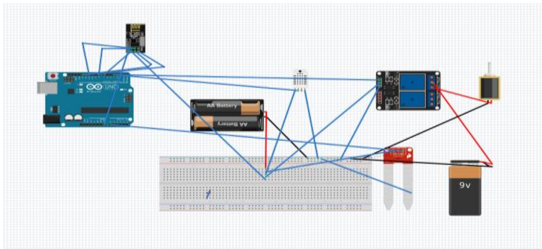

Fig. 3 Circuit Connection of Control Unit on the Breadboard

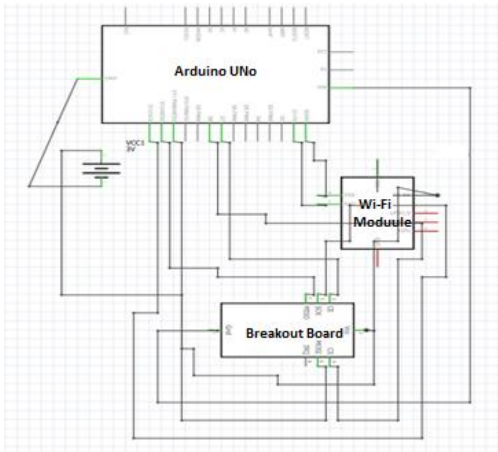

Fig.4 Circuit Diagram for the Receiving Unit

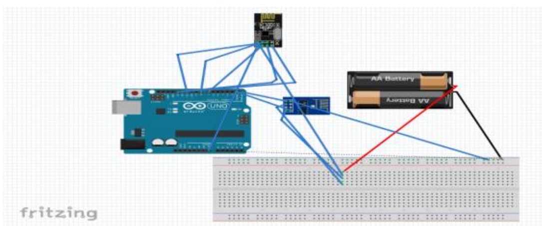

Fig. 5 Circuit Connection of Receiving Unit on the Breadboard

The connection diagram of the receiving unit and its implementation on the breadboard are shown in the Fig. 4 and 5 respectively. The receiving unit consists of an Arduino, an nRF24l01, an ESP8266 and batteries. The receiving unit is kept near the farmer's home.

3. HARDWARE IMPLEMENTATION

The operational diagram for the proposed system is shown Fig. 6

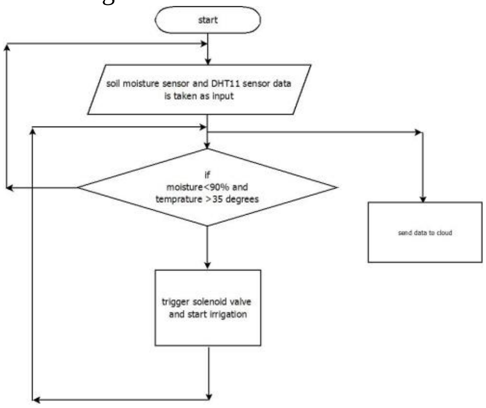

Fig. 6 Operational diagram for the system

As shown in Fig. 6 it can be seen that the given threshold value for the triggering action of the actuators are specified. If the soil moisture percentage or temperature of soil drops below the threshold value, the solenoid valve is triggered, else it doesn't irrigate the field. And simultaneously the data will be transferred to the internet. Prototype of the proposed model is shown in Fig. 7

In the proposed model, main control unit senses moisture content and soil temperature. A fixed value is used as reference to trigger the solenoid valve. If the temperature is 40^{0}c and humidity is 50%, the irrigation starts. The relay coil gets a signal from Arduino to trigger the solenoid valve. Assuming the water is present in the tank, the water starts flowing through the valve. Further, after some time, once the moisture content reached 100% and temperature dropped to 30^{0}C, the process stops immediately. The process repeats itself again and again. Simultaneously the moisture percentage, temperature and humidity will be transferred to the ThingSpeak platform through the nRF24L01 for monitoring purpose.

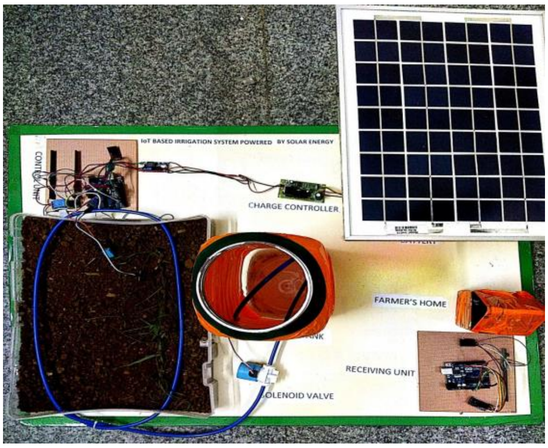

Fig. 7 Experimental setup of proposed system

Solar charge controller circuit

Solar charge controller is a tool used to regulate voltage or current, and to avoid overloading of the battery. The charge controller circuit ensures that the batteries of the deep cycle are not overloaded during the day and that the power is not running overnight back to the solar panels and draining the batteries. The circuit diagram of solar charge controller is shown in Fig. 8

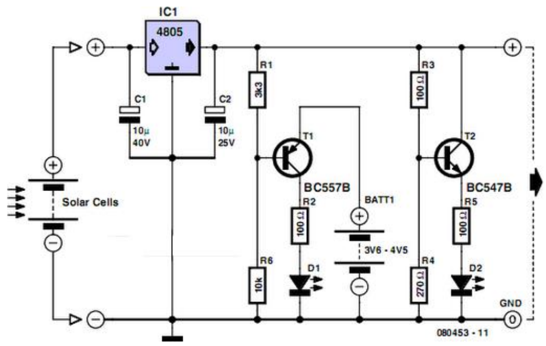

Fig. 8 Solar cell voltage regulator circuit diagram

The charge controller uses a LM317 voltage regulator. The LM317 is a three-terminal positive voltage regulator that can produce more than 1.5A over a voltage output range of 1.25 V to 37 V. Setting the output voltage only requires two external resistors. It includes current restricting, defense against thermal overload and safe defense of operating area. The specifications of the circuit is shown in Table. 2

Table 2. Specifications of the circuit

Parameter	Value
Output voltage	1.25 - 37V
Voltage differential	3 - 40V
Operating temperature	0-125 °C
Max. output current	1.5 A
Min. load current	3.5 to 1 mA
Thermal resistance	80 °C/W
Thermal resistance	4 °C/W

ThingSpeak Platform

ThingSpeak platform is free web server and a web page run by MATLAB. This platform receives information from devices linked to the internet. And then the website shows the data in the form of graphs. The homepage of the ThingSpeak Platform is as shown in Fig. 9.

Fig.9 ThingSpeak platform

It is required to create an ID here, and then to request for a API key. The API key is unique key which helps in sending data to their platform. In the proposed system the Transmission Control Protocol (TCP) is used for sending data. It is also required use their IP addresses to send data to their server.

Formulation and Testing

Calibration of YL-69 a Chinese make soil moisture sensor is carried out in the paper. It is done by measuring the soil moisture value when the soil is dry. Then small amount of water is added in successions to plot the graph of the curve. A map the obtained values for the usage in the program. Experimental configuration of the proposed scheme is shown in Fig. 10. Materials required for testing is show in Tbale.3.

Fig.10 Experimental Setup

Table 3. Material required

Si No.	Material	Quantity
1	Burette	1
2	Black soil and red soil	250gms
3	Arduino UNO	1
4	Soil moisture sensor	1

4. RESULTS

The water is poured into the burette and placed on the stand as shown in the Fig. 10. Sensor of soil moisture is put in the soil and positioned under the burette stand. The Arduino is programmed with the code necessary for processing and open the valve of the burette. Small amount of water is allowed to pour as per the changes in readings. Finally the results are tabulated as shown in Table. 4 and plotted on the graph as shown in Fig. 11.

Table 4. Readings of soil moisture sensor

Sl No	Volume of water (mL)	Reading of soil moisture sensor for Black soil	Reading of soil moisture sensor for red soil
1	0	913	917
2	2	496	589
3	6	355	400
4	20	326	350
5	25	307	308
6	30	292	293
7	40	290	290

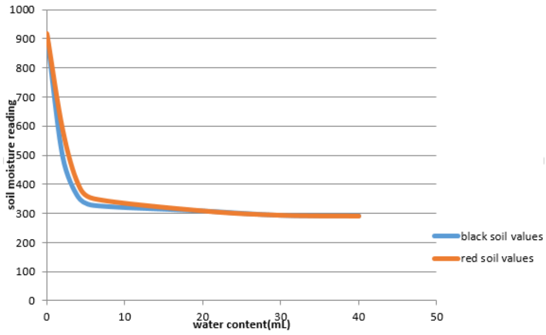

Fig. 11 Soil Moisture Sensor reading vs soil Content

As shown in Fig. 11 it is evident that the soil moisture sensor readings are similar for different types of soil. So we can assume that-

$$0\% --> 915$$
$$100\% --> 290$$

Thus setting minimum value as 915 and maximum value as 290, it can be mapped for each value obtaining the required result in percentage.

The obtained data is transferred to the ThingSpeak platform at the baud rate of 115200. The three parameters transferred to ThingSpeak is shown in the Fig. 12, the protocol used and the API key for our field used can be seen.

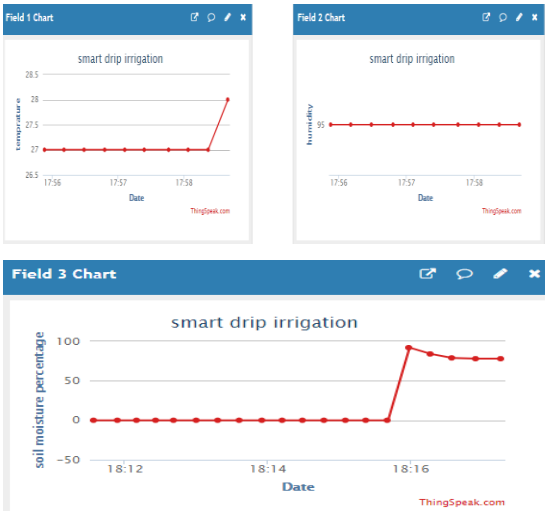

Fig. 12 Data transferred to ThingSpeak platform

The temperature, humidity and soil moisture being transferred to the ThinSpeak platform. The time of the data transfer can also be noted from the graphs. The data is uploaded four times in a minute. It can be changed by increasing or decreasing the delay in the program. Thus we can monitor the changes happening in the field using this system. Also this system being automatic, it reduces labour issues. The other main advantage of using this system is that we don't need internet connectivity in the field like other existing technology. It just needs Wi-Fi in the home of the farmer.

5. CONCLUSIONS

This paper proposed the issues related to irrigation system and an innovative method to solve the problems faced by farmers. Over irrigation and under irrigation is one of the major problems faced by paddy cultivators. The proposed system has emphasized on the usage of drip irrigation which according to the above discussion is known to improve the yield by up to 50%, save up to 70% of water and also save energy as this is system is powered by solar energy. It has also proved that with the usage of drip irrigation combined with sensors and IoT it can further improve the yield especially in the case of sub surfaced drip irrigation which must require a monitoring system. The proposed system also turns out to be effective when the area of the field becomes large, as irrigating and monitoring large fields usually takes large amount of time and energy. This system can help save the time, money, power and water crises of the farmer.

ACKNOWLEDGMENT

Authors would like to express their sincere thanks to the Vice Chancellor and Management of M S Ramaiah Applied Sciences University, Bangalore for providing all the facilities needed to carry out this research work.

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